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IMPACT OF AN OFFSHORE WIND FARM ON WAVE CONDITIONS AND SHORELINE DEVELOPMENT

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INTRODUCTION

During recent years the relative shallow waters in the North Sea and the inner Danish waters and the Baltic Sea have been subject to an intense planning and construction of offshore renewables, mainly offshore wind farms, but lately also wave energy converters and tidal turbines. This will have a local and regional impact on the wave and current conditions and therefore also on for instance sediment transport, and on the shoreline development.

IMPACT ON WAVE CONDITIONS

(Christensen et al., 2013) describes the impact of offshore wind farms on the wave conditions. Generation of wind waves is governed by the surface shear stress on the water surface due to the wind, the fetch, the depth and the duration of the storm. When the waves meet the offshore wind farm the wave field can be altered due to three significant processes that have to be considered, which are; a) the dissipation due to drag resistance, b) reflection/diffraction of waves around the structure, and c) the effect of a changed wind field inside and on the lee side of the offshore wind farm.

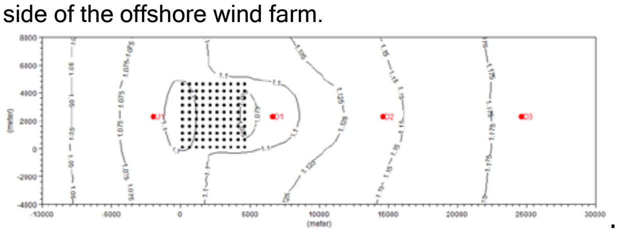

Figure 1 Set up of the offshore wind farm in (Christensen et al., 2013). Wind turbines: •, Extraction points:•D1

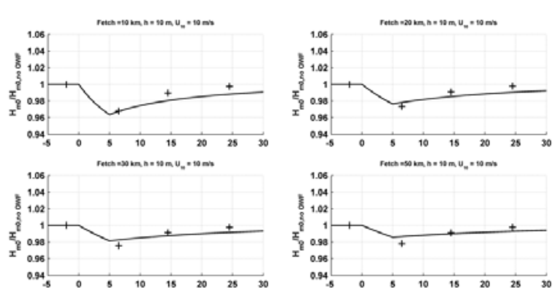

Figure 2: The relative effect of the OWF on the wave height for different fetches. The OWF is located from Dist = 0 km to 5 km.

The turbines in operation extract energy from the wind but also act as obstacles to the wind. These two processes change the wind field inside and on the lee side of the wind farm. These effects were studied by implementing parameterised models in the spectral wind wave model MIKE21 SW. The set-up is illustrated in fig 1, which also shows the wave contours for a case where all three effects are included.

The results above indicate that the wave height can easily be reduced in the order of 4-5 % 2 km down-wind of the OWF, and in the order of up to 2 % 10 km down-wind. The direction of the incoming waves is modified as well.

IMPACT ON SHORELINE DEVELOPMENT

The impacts on nearshore wave climate from the OWF are coupled to shoreline evolution by use of a one-line model, LITLINE. Assuming a wave angle of 25 deg. relative to the coastline, simulations indicate that the longshore transport is reduced by 10 % for an OWF located 5 km from the coast and by 4 % for an OWF located 15 km from the coast. This causes shoreline changes with formation of a salient in the lee of the OWF and shoreline erosion along the downdrift areas (see fig 3). The time scale for the shoreline evolution is several centuries and the equilibrium situation for the upper panel in fig 3 has shoreline movements of about 100 m.

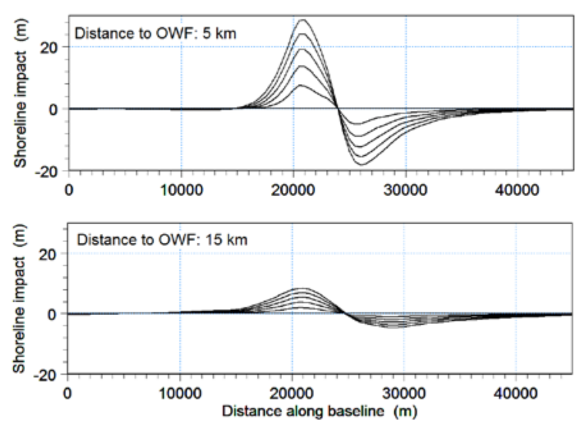

Figure 3: Simulated shoreline impact from OWF's located at different distances from the coast. Shorelines are shown every 10 years.

REFERENCES

Christensen, E.D., Johnson, M., Sørensen, O.R., Hasager, C.B., Badger, M., Larsen, S.E., 2013. Transmission of wave energy through an offshore wind turbine farm. Coast. Eng. 82, 25-46.